Comments from Reviewer #1

We thank the reviewer#1 for the valuable suggestions and constructing comments. This GMDD manuscript has been modified accordingly. Point-to-point response to the reviewer's comments is given below.

Dear Authors,

Thank you for your well-written and interesting manuscript. This topic of aerosol-aware DA is a frontier of development in data assimilation and this paper represents an important milestone in that development.

I have minor recommendations for clarity and completeness to make this manuscript more helpful to readers and eliminate some ambiguity in your descriptions. I did not identify any technical changes needed in the work you describe.

- I recognize that CRTM is well-described in other publications, but I think it is still appropriate to add some more text describing how the aerosol and RT modules interact. CRTM is a "fast radiative transfer model," which means that certain computations are done ahead using a more complete analytical model, with solutions stored in lookup tables used by CRTM. What aspects of the RT are solved via lookup tables and which ones are solved analytically is important information for understanding how this system reacts to the additional information about scattering and absorbing particles.

  The 2nd paragraph in Section 2.2 CRTM aerosol module has been revised. The following text is added (line 118-124): Absorption by atmospheric trace gases, such as water vapor and carbon dioxide, is parameterized using the Optical Depth in Absorber Space (ODAS) and the Optical Depth in Pressure Space (ODPS) algorithms (Chen et al., 2012), which are based on rigorous line-by-line calculations from the Line-By-Line Radiative Transfer Model (LBLRTM, Clough et al., 1992). Scattering and absorption by aerosols are calculated based on pre-computed lookup tables containing aerosol optical properties, including extinction coefficient, single-scattering albedo, asymmetry factor, and phase function coefficients. Operationally, given aerosol types, radius, concentration and ambient relative humidity, CRTM generates aerosol optical profiles that the radiative transfer solver requires for multi-scattering simulations and radiance calculations.

- Line 58-60: aerosol-aware DA is complicated to describe, because the model prior has high and low biases without aerosol information and different high and low biases when aerosol information is included. This part needs to be looked over carefully, especially the part about "leads to a warmer atmospheric analysis" needs a more complete description that reduces ambiguity about the referenced experiment and results.

  This paragraph has been revised by providing a more complete description of referenced experiments (line 55-62) and the results (line 65-67).

  Figure 2 and discussion in Lines 217-222: This part of the description seemed rushed and incomplete. There is plenty of room to expand this figure to show, for instance, the relationship between dust loading and differences in innovations.

Figure 2 in the previous version contains global BT differences and OMFs differences over the trans -Atlantic region. This figure has been revised to BT differences, OMFs for CTL, OMFs from AER, and OMFs differences over the trans-Atlantic region (Figure 3). We also add a new figure (Figure 4) showing the OMFs differences versus dust loading. The discussions on these 2 figures are also extended (line 237-250).

- Line 70: "In section 2.3,… given here." => "In section 2.3,… is given."

  Revised. "is given here" changed to "is given." (line 77). We also revise line 196 ('given here' changed to 'given').

- Line 96: "may degrade the data usage" It is not clear what this means.

  This phrase is clarified. Line 105: 'degrade the data usage' changed to 'fluctuate the amount of observations assimilated'

- Line 140: "optical properties… are"

  Corrected. "is" changed to "are". (line 157)

- Line 292: "include, but not" => "include, but are not"

  Corrected. "efforts include, but not limited to" changed to "efforts include, but are not limited to" (line 363)